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ABSTRACT

The experiment employed Sternberg's procedure to investigate the effects of presentation and test modalities (auditory or visual), and number of presentations on the processing rate of monosyllabic words of varying graphemic and phonemic length. Twenty college students and 20 sixth graders served as Ss. Each S received all conditions and lists in a 10 x 10 graeco-latin square design. The main results were: (a) short high frequency words were processed at approximately the same rate as single digits; (b) all combinations of presentation and test yielded approximately the same processing rate except for visual auditory combination which was much slower; (c) there was no difference due to the age of the Ss; and (b) number of presentations and word length had no consistent effects. (Author)

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THE EFFECT OF PRESENTATION AND TEST MODE ON SHORT-TERM RETENTION OF WORDS

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Technical Report No. 68

THE EFFECT OF PRESENTATION AND TEST MODE ON SHORT TERM RETENTION OF WORDS

By Susan L. Goldring

Report from the Project on Language Concepts and Cognitive Skills
Related to the Acquisition of Literacy
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PREFACE

Contributing to an understanding of children's cognitive learning and improving related educational practices is the goal of the Wisconsin R & D Center. One of the Center's three major research and development programs—Conditions and Processes of Learning—consists of laboratory-type research projects, each concentrating on certain basic organismic or situational determinants of cognitive learning, but all united in the task of providing knowledge which can be utilized in the construction of instructional systems.

While their long-term goal is the construction of materials which will optimize reading acquisition, Professors Calfee and Venezky are presently attempting to gain a better understanding of the fundamental independent cognitive skills related to the reading process. Miss Goldring used a procedure developed by Sternberg to measure the rate at which verbal items were processed during a recognition memory test. The procedure was used to determine processing rate of monosyllabic words in both sixth-grade and college students. Her results showed that processing of lists of familiar words occurred at about the same rate as the lists of digits or numbers which other investigators had used and confirmed previous findings that development of processing skills needed for such a task is completed by the sixth grade.

Herbert J. Klausmeier
Director

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CONTENTS

		page
	List of Tables	vi
	Abstract	vii
I	Introduction	1
II	Preliminary Experiment	3
III	Main Experiment	5
IV	Discussion	8
	Appendix A: Word Groups	10
	Appendix B: Supplementary Tables	12
	References	17

LIST OF TABLES

Table		page
1	Composition of the Word Groups in Terms of Phonemic and Graphemic Length of Words in Each Group	3
2	Mean Percentage of Correct Responses for each Task Condition and Presentation Rate in the Preliminary Experiment	4
3	Mean Processing Rate per Item for Each Condition and Word Group in the Main Experiment	7
4	Minimal Pairs Analysis of Word Groups	9
B1	Analysis of Variance for Each Task Condition in the Preliminary Experiment	12
B2	Percentage of Errors for Each Condition and Word Group	13
B3	Mean Intercepts for Each Condition and Word Group	13
B4	Analysis of Variance of Processing Rates in the Main Experiment	14
B5	Mean Processing Rate per Item for Items in Each Word Group under the two Conditions of Number of Presentations	15
B6	Mean Processing Rate per Item for Items in Each Word Group for each Test Modality	15
B7	Mean Processing Rate per Item for Items in Each Word Group for Each Presentation Modality	16

ABSTRACT

The experiment employed Sternberg's procedure to investigate the effects of presentation and test modalities (auditory or visual), and number of presentations on the processing rate of monosyllabic words of varying graphemic and phonemic length. 20 college students and 20 sixth graders served as Ss. Each S received all conditions and lists in a 10 x 10 graeco-latin square design. The main results were: (a) short high frequency words were processed at approximately the same rate as single digits; (b) all combinations of presentation and test yielded approximately the same processing rate except for visual-auditory combination which was much slower; (c) there was no difference due to the age of the Ss; and (d) number of presentations and word length had no consistent effects.

I
INTRODUCTION

The research of Conrad (1962, 1964; Conrad & Hull, 1964) and Wickelgren (1965a, 1965b), showing acoustic confusion with visually presented digits and letters, indicated that this material was stored in an acoustic form. If all verbal material is transformed to an acoustic format in memory, then one might expect that auditory presentation and test would lead to the fastest processing rates and that visual presentation and test would take longer because of the required conversion to an acoustic format. Following the argument further, if the presentation rate were slow enough to allow an input to be converted to an acoustic representation before S had to act upon it, then only the modality of the test item would be important. Under these circumstances reaction time (RT) to an auditory test should be faster than to a visual test.

Chase and Posner (1965) did not find slower processing of acoustically confusing letters. Sternberg (1967) presented evidence that visual representations were used in the operation of comparison, but was not led to conclude that the list of words in memory with which the test word must be compared was retained visually. He stated that "the occurrence of 'acoustic confusions' in the recall of visually-presented characters does not per se imply acoustic storage, but only an acoustic representation at some stage." Assuming the existence of higher order storage, mode of presentation and test would make a difference only in the time it takes to convert a visual or auditory test item to this higher order form. Thus, if conversion from one mode into the higher form took longer than converting from the other mode, then longer processing rate would result.

Sternberg (1966, 1967) has demonstrated the usefulness of RT as an indication of processing rate. He found that RT increased linearly with the number of items which were to be compared with the test item. Further, the linear function held whether the test item was positive or negative, suggesting that memory search was exhaustive. The slope of RT as a function of size of the memory set was determined by finding the median reaction time for each set size and fitting these data with a straight line by the method of least squares. The slope is then used as a measure of processing time, and the intercept represents preprocessing time. In all previous research on processing rate and acoustic confusions, single letters or digits have been employed as stimuli.

The present study consisted of a 2 x 2 x 2 design combining mode of presentation (auditory or visual), mode of test (auditory or visual), and number of times the list was presented (one or four). Combinations of presentation and test mode will be referred to by an ordered pair, so that AV means auditory presentation, visual test. High frequency monosyllabic words presented serially at a .5-sec. rate served as stimuli. Repetition of the list four times allowed S to see each word for a total time of 2.0 sec., as opposed to .5 sec. per word when the list was only presented once. Assuming that 2.0 sec. is long enough to allow the conversion of stimuli to an acoustic format during input, and assuming acoustic storage, one would predict that at the 2.0-sec. presentation time processing rate would be most rapid for the conditions of auditory test since only the test item need be converted. If it is also assumed that .5 sec. is not sufficient for conversion, then S would need time after presentation of the test items to complete conversion to an acoustic mode before storage. Therefore, AA would still have the fastest RT and VV would have the slowest, while VA and AV would fall somewhere in between.

If, on the other hand, verbal material is handled equally well in both modalities (Carterette & Jones, 1967, gave some evidence that this was true by the fifth grade), but with difficulty when modalities are mixed, then the prediction would be that AA and VV would both have faster RTs than AV and VA, regardless of the presentation time.

With serial presentation at the rates used, it is likely S can verbalize the stimuli, so two conditions were added in an attempt to reduce the extent of such verbalization. In these conditions, the stimuli were presented simultaneously for .75 sec., followed by a visual or auditory test. In a preliminary study this interval yielded an 85-90% success rate in a four-word recognition task.[1] The expectation was that under these presentation conditions, changing the test mode would slow up processing, so that VA would be worse than VV. If acoustic storage is used, then S should do poorly under these two conditions since little time would be available for conversion of the material to an acoustic representation.

The effects of rate and repetition were investigated by Mackworth (1965) who manipulated presentation rate, number of letter pairs, number of repetitions. She found that (a) a fast presentation rate led to better recall than a slow presentation rate, (b) the improvement due to repetition was greater at the slower rates, and (c) increased length reduced recall more with the faster than the slower rate.

In addition to the variation in presentation and test conditions, the effects of graphemic and phonetic length of the stimulus words was also explored in the present study. It was hypothesized that graphemic length might affect visual presentation and test, while phonetic length might affect auditory presentation and test. However, two studies (Postman & Adis-Castro, 1965; McGinnies, Comer, & Lacey, 1952) reported that tachistoscopic thresholds varied with word length only for low frequency words.

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[1] Landauer (1962) indicated that a .75-sec. rate would be faster than the time required for internal speech. Sperling (1966) agreed with this although he suggested a slightly faster rate for internal speech than Landauer found.

II
PRELIMINARY EXPERIMENT

A preliminary experiment was run to determine the shortest time for simultaneous visual presentation of verbal material not exceeding a minimal error rate. Both a recall and a recognition task were used in the preliminary experiment.

METHOD

Materials

Five groups of high frequency monosyllabic words were selected with phonemic and graphemic lengths as shown in Table 1. Groups A through D each contained 42 words. In Group E, because of the length of the words and the requirement that they be monosyllabic and high frequency, the number of available words was severely restricted and only 28 words could be found which satisfied all the constraints. All groups were equated for frequency of occurrence of first letters. No group contained more phonemes than graphemes since only a few graphemes allow for such an occurrence, and then only in special cases (e.g., x as in box /baks/, or c as in cello /čelo/).

Table 1

Composition of the Word Groups in Terms of Phonemic and Graphemic Length of Words in Each Group

	Word Groups				
	A	B	C	D	E
Phonemes	3	3	4	4	≥5
Graphemes	3	4	4	5	≥6
Examples	big ton	load rail	help risk	heart faint	strength glimpse

The words were chosen with the following additional restrictions:

a) homophones and proper names were not used;
b) a final silent letter was not allowed in Group B because it might change a word from Group A to Group B (e.g. hat, hate; bit, bite);
c) diphthongs (/aɪ, au, ɔɪ, ju (or ɪu)/) were not allowed because of the tendency to pronounce them as two phonemes;
d) plural forms were not used;
e) words containing /ə/ as in bird, were not used because of the question of whether /ə/ is one or two phonemes;
f) /č/ and /ǰ/ were eliminated because they may be considered two phonemes;
g) letters representing more than one phoneme (e.g. box /baks/) were not used.

The word groups are presented in Appendix A.

Design and Procedure

The experiment used a 2 x 2 between Ss design of presentation time (.50 sec., or .75 sec.) combined with task (recall or recognition). Five Ss assigned randomly to each of the four cells in this design received the stimulus words from Groups A-E in an order determined by a 5 x 5 latin square. The stimuli consisted of 4-word lists which were typed horizontally on 5" x 7" cards. Ten such 4-word lists were selected for each of the five word groups. An additional five lists using different words were selected for pretraining.

In the recognition task, each 4-word list was displayed tachistoscopically for the appropriate presentation time. Immediately thereafter, S was given a response sheet with eight words and was asked to circle the four words he had just seen. The four new items on the response sheet were selected at random from the same word group as the presentation group. In the

recall task following each presentation, S was asked to say the four words aloud, and E recorded his responses. A different random order for presentation of the 4-word lists was selected for each S. All Ss responded within the 15-sec. time limit allowed.

Subjects

Twenty male and female students enrolled in an introductory psychology course at the University of Wisconsin served as Ss. The Ss were volunteers and received experimental credit for participating in the experiment.

RESULTS

Analyses of variance were performed on each of the two task conditions (Table B1).[2] In both analyses the effect of presentation time was significant (recognition, $F(1, 8) = 9.22$, $p < .05$; recall, $F(1,8) = 13.19$, $p < .01$), with significantly fewer errors being made at the longer time interval (Table 2). There was also a significant effect of word group (recognition, $F(4,32) = 4.79$, $p < .01$; recall, $F(4,32) = 5.11$, $p < .01$). Groups D and E were more difficult than the other lists. The time by word-group interaction was not significant for either task.

Table 2

Mean Percentage of Correct Responses for Each Task Condition and Presentation Rate in the Preliminary Experiment

Task	Time of Presentation	Word Groups				
		A	B	C	D	E
Recall	.50	59	61	59	49	50
	.75	79	74	75	70	62
Recognition	.50	76	76	77	72	72
	.75	87	92	92	84	80
Average		75	76	76	69	66

The main purpose in running the preliminary study was to determine the error rates for presentation times of .50 sec. or .75 sec. The mean error rate of 13% at the .75-sec. presentation time was judged sufficiently small for purposes of the main experiment.

[2] Tables with a B before the number are supplementary tables and appear in Appendix B.

III
MAIN EXPERIMENT

The main experiment used Sternberg's (1966) RT recognition task to investigate performance as a function of manner of presentation (auditory or visual), manner of test (auditory or visual), and number of presentations (one or four times) with a serial presentation of the stimuli. The rate of presentation for all serial lists was .5 sec. per item. Thus in the case of only one presentation each item was seen for a total time of .5 sec., while in the case of 4 presentations each item was seen for a total time of 2.0 sec.

METHOD

Materials

The lists were drawn from the five word groups described earlier. Within each group, eight lists of 1, 2, or 4 words each were selected, yielding 24 lists for each word group. There were an equal number of positive and negative tests. For 12 of the lists, a test item was chosen from the list, for the other 12, a negative item was chosen at random from the remaining words in the group. Each position in the list occurred equally often as a positive response. Two random arrangements were prepared for each set of lists. A list or a test item never occurred in either the immediately preceding or succeeding list and test.

Design

The basic design consisted of a 2 x 2 x 2 factorial combination of presentation mode (auditory or visual), test mode (auditory or visual), and number of presentations (one or four), serial presentation at a rate of .5 sec. per item being used in all these conditions. Two additional conditions, simultaneous presentation with either auditory or visual test, were included. The duration of the simultaneous presentation was .75 sec.

The ten lists formed by the two random orders of each of the five word groups were combined with the ten experimental conditions in a graeco-latin square design. Each S received a different combination of each condition and word group. This design did not permit the direct analysis of word group by conditions interaction. The graeco-latin design was selected because the preliminary experiment did not indicate large differences between word groups and the size of the experiment with a complete factorial design would have been impractical.

Procedure

In the procedure of Sternberg (1966), a memory list was presented, followed by a test item, whose onset activated a timer. The S had to respond YES or NO to the test item depending on whether it was in the memory set or not. The response stopped the timer, yielding a reaction time (RT). Sternberg found that RT was a linear function of the number of words in the stimulus set. The slope of the function was interpreted as the processing rate per item in memory.

In the present study, the auditory stimuli were recorded on a stereo tape-recorder. The presentation series was recorded on one track. First, the number of items in the memory set was given, followed 1 sec. later by the items at a .5-sec. rate. One sec. after the last item in the memory set, a bell was sounded as a pretest signal. One sec. after the bell, and on the other track of the tape, the test item was presented. A voice-operated relay tripped by the test item started a clock which S stopped when he pushed one of the response buttons. Five seconds later, the S heard the memory set size for the next list.

For visual presentation of the memory set, S looked at an MTA Scholar, a memory drum which allowed display of the material at a fixed

rate. First S saw the list length number followed 1 sec. later by the words in the memory set, either one at a time at a .5-sec. rate in serial presentation, or the entire set for .75 sec. in simultaneous presentation. One sec. after the last item, S heard the warning bell for the test.

For the VV condition (during the 2.0-sec. interval between the end of the stimulus list and the test word) the S was required to shift to a Polymetric tachistoscope used to present the test word. The tachistoscope was activated by the test word on the tape-recorder at the same time that the clock was started. Thus, the tape-recorder was used to present S with the warning bell on one track and to activate the tachistoscope and the clock on the second track. The warning bell was used as the preliminary signal for the test word under both auditory and visual test conditions. The visual test item was typed in capital letters centered in the tachistoscopic display. It was visible for approximately 2.0 sec., but the S was instructed to respond as quickly as possible. Following the test, the S again directed his attention to the MTA Scholar which he started by pushing a button. The interval between the test item and the beginning of the next list was approximately 5.0 sec.; since the S controlled the onset of the MTA, the time could not be controlled as precisely as it could be for the auditory presentation. For the AV condition the S listened to the list, heard the warning bell and looked into the tachistoscope to see the test item.

The time required for the response and the response itself were written down by the experimenter and also punched on an IBM card by an automated card punch system. The punched data were accurate to 1 msec. and were used in preference to the hand recorded data, except in a few cases where a punching error occurred.

Each S served in six sessions, the first being an orientation and pretraining session in which he had a chance to practice under each condition. During the training session each S also completed a biographical information form and looked over the list of words to make sure that he recognized all of them. On each of the following five sessions two group-condition combinations were tested. Each session took between 20 and 30 minutes. The S was informed before each 24-trial block what the presentation and test conditions would be. Most Ss completed two sessions a week, although occasionally an S missed a session.

Subjects

The experiment was replicated four times, twice with college students and twice with sixth graders. There were 10 Ss in each replication. The college students consisted of 7 men and 13 women with a median age of 20, a mean grade point average of 2.73, and a median class standing of junior. All Ss were born in the U.S. and spoke English as their native language. The sixth-grade subjects consisted of 10 boys and 10 girls with an average age of 12 years 2 months and a mean grade of B. One S was not a native of the U.S. but had moved here before the age of 1 year.

All Ss were volunteers and were paid for their participation in the experiment. The college students received $2.00 an hour and the grade school children were paid $ .50 a session, plus bus fare. The reduced rate for the sixth graders was on recommendation from the parents who felt that $2.00 an hour was too much for children of that age.

RESULTS

The primary dependent variable was processing rate, as measured by the slope of RT as a function of the size of the memory set. All error times were disregarded. The median RT for positive and negative tests at each set size was then determined for each condition. A linear function was fit by the method of least squares to each data set. There were no consistent departures from linearity, nor did the slope on positive and negative tests differ markedly, and so the slope parameter based on the combined (positive and negative) test was used as the estimate of processing rate. The error rate (Table B2) generally was less than 5%, and errors were distributed more or less equally across all conditions. The sixth graders made more errors under simultaneous presentation, and there were fewer errors in both age groups at four than at one repetition. The intercepts were quite variable, as is not uncommon in this type of research (Table B3). The most apparent effect was the difference between sixth graders (583 msec.) and college students (486 msec.).

The mean processing rate per item was 51 msec., which may be compared to the rates of 38 msec. reported by Sternberg (1966, 1967) and 53 msec. reported by Chase and Calfee (1968) for single digits and letters.

An analysis of variance was performed on the processing rates (Table B4). Nonsignificance of Squares, $F(2, 36) = 1.53$, $p > .25$, indicates the equivalence of the two replications. Age level was also not significant, nor did age level interact with any of the other variables. There

were no significant developmental differences between college students and sixth graders in their processing of verbal material under the conditions of this experiment.

The conditions variable was partitioned by means of orthogonal comparisons. Presentation mode was significant, $F(1, 317) = 4.21$, $p < .05$, indicating a slightly faster rate for auditory presentation compared to visual presentation. The more interesting result was the significant Presentation by Test interaction, $F(1,317) = 6.13$, $p < .05$. A Duncan range test indicated that the VA condition differed significantly ($p < .05$) from the other serial presentation conditions (Table 3).

Simultaneous presentations led to longer processing times (58.9 msec.) than successive (48.2 msec.), $F(1, 317) = 9.18$, $p < .01$ and Sim-A differed significantly from Sim-V $F(1, 317) = 9.01$, $p < .01$. The number of repetitions of a list had no significant effect on processing rate for high frequency words.

The main effect of Word Groups was not significant, $F(4, 317) = 2.11$, $p < .10$. An attempt to get an estimate of the existence of interactions between Groups and Presentation mode, Groups and Test mode, and Groups and Number of presentations was carried out, collapsing over all variables except the pair being considered (Tables B5, B6, and B7). Multiple t tests were run for the combined data for each interaction. Although some of the differences between individual pairs of means were significant, there was no consistent pattern to the results. It should be noted that these comparisons are not altogether legitimate, since the various comparisons are confounded by subject selection associated with the graeco-latin design.

Table 3

Mean Processing Rate per Item for Each Condition and Word Group in the Main Experiment

Subjects	Number of Presentations	Presentation-test Condition					
		Successive				Simultaneous	
		AA	AV	VA	VV	A	V
College	1	36.5	37.5	64.0	48.0	82.0	51.0
	4	37.5	35.5	52.0	48.5		
	Combined	37.0	36.5	58.0	48.25	82.0	51.0
6th Grade	1	51.0	59.0	69.5	40.0	69.0	43.5
	4	39.5	53.0	55.0	43.0		
	Combined	45.25	56.0	62.25	41.4	69.0	43.5
Combined	1	43.75	48.25	66.75	44.0	70.5	47.25
	4	38.50	44.25	53.50	46.25		
	Combined	41.12	46.25	60.12	45.12	70.50	47.25

Subjects	Word Groups				
	A	B	C	D	E
College	44.0	40.5	54.5	45.5	62.5
6th Grade	53.5	50.0	58.0	46.5	55.5
Combined	48.8	45.3	56.3	46.0	59.0

IV
DISCUSSION

The absence of significant developmental differences between the sixth graders and the college students agrees with the finding of Carterette and Jones (1967) that verbal material is handled equally well in both auditory and visual modalities after the fifth-grade reading level is attained. Chase and Calfee (1968) have reported that presentation and test of letters of the alphabet in the same modality produced a faster processing rate than when there was a change in modalities. Postman and Rosenzweig (1957) in a different type of experiment reported lower recognition thresholds and fewer errors within the same modality. Between modalities they found a lower threshold with the VA condition compared to the AV condition.

In the present study, the VA condition led to a slower processing rate than the other conditions of presentation and test. The difference was from 15-20 msec. and appeared under both successive and simultaneous presentation. This result is at variance with Chase and Calfee (1968) and Postman and Rosenzweig (1957) in important details, but all three studies indicate that cross-modality shifts produce poorer performance than when presentation and test are in the same modality.

One might argue that a single visual presentation was insufficient for transformation to an acoustic format, hence the slower rate of processing in the VA condition. However, four repetitions should be sufficient for overt verbalization (if necessary) and certainly for acoustic encoding. Accordingly, with four repetitions, the VA condition should not differ from the others. To be sure, repetition did reduce the difference, but not sufficiently to bring the processing rate down to a level comparable to the other conditions. Consider the possibility that the representation in memory is in the same mode as the presentation, and that comparisons are made in that mode. Then in the AA and VV conditions no changes are needed before the test item can be compared with the presentation set. However, in the mixed mode conditions, the test item must be changed before comparisons are made. Suppose that (oral) reading is easier than producing a spelling of a spoken word. This assumes that it is relatively easy to verbalize a written word, thereby giving it an acoustic representation, especially for highly familiar words. On the other hand, transforming an acoustic test word to a visual representation for comparison with visually presented stimuli is a more difficult task. Even familiar words may present spelling difficulties because of the spelling irregularities of English. In the VA condition, S first converts the test word to a written and hence spelled visual representation, then checks that representation against some storage of the correct spelling. Only after he is reasonably satisfied that the visual representation is correct can he complete the search task.

To the extent that this explanation is correct, uncommon or synthetic words should produce still greater discrepancies between the VA condition and other conditions. Synthetic words might also lead to an increased processing rate for the AV condition because S would be less certain about the pronunciation of a word, and might have to try several different pronunciations before finding a satisfactory one.

Given that high frequency words constituted the stimulus material, it is not too surprising that the effects of word groups were minimal. In looking over the word groups after the study, it was noted that there was no control for the number of minimal pairs, such as list-lost, or park-lark. About 25% of the words in Groups A and C were minimal pairs, compared with less than 5% in the other groups (Table 4). This post hoc analysis may account for the slightly slower processing rate of items in Groups A and C, and it bears further investigation. Increasing the number of minimal pairs, especially by rhymes, might lead to some interesting results.

Table 4

Minimal Pairs Analysis of Word Groups

Type of Minimal Pair	Word Groups				
	A	B	C	D	E
Vowel	4	1	4	0	0
Conso-nant	10	3	7	2	0
Total	14	4	11	2	0

Note.—A vowel minimal pair occurs when two words differ only by the vowel, e.g. hot and hat. A similar consonant minimal pair would be hat and bat.

Material can be selected to yield rhyme-type matches in three distinct ways: acoustically and visually like sing and ring; acoustically only like keen and mean; and visually only like mother and bother. One might expect that acoustical rhymes would facilitate the AA condition and be detrimental to the VV condition. Words that rhyme both acoustically and visually should lower the processing rate in all conditions; of particular interest would be the effects on mixed mode conditions. In the VA condition, the transformation from spelling to sound might be easier if all words followed similar spelling and sound patterns.

APPENDIX A
WORD GROUPS

(Groups divided according to Thorndike-Lorge (1944) frequencies, with Howe (1966) frequencies given for each word)

A		B		C		D		E	
AA	H	AA	H	AA	H	AA	H	AA	H
Act	11	Draw	11	Bank	28	Black	54	Brought	59
Bad	116	East	22	Camp	24	Build	34	Friend	58
Bag	15	Fish	18	Cold	23	Court	15	Length	11
Bed	57	Gain	8	Cost	23	Fence	2	Prince	2
Big	223	Half	141	Dark[a]	15	Field	51	Spread	5
Car	112	Head	53	Fast	43	Force	42	Spring	7
Cup	12	King	10	Hand	67	Fresh	14	Square	13
Cut	51	Laid	12	Help	73	Fruit	10	Strength	4
Dog[a]	35	Long	176	Kept	43	Heart	20	Strong	18
Fat	5	Nail		Land	20	North	42	Twelve	55
Hat	6	Near	43	Last	207	Paint[a]	2		
Hot	36	Neck	13	Left	111	Place[a]	258		
Leg	51	Path		Lord		Short	27		
Let	150	Rush	7	Lost	33	Space	22		
Lip		Sick	44	Mark	10	Thank	14		
Man	88	Sing	11	Milk	76	Taste	4		
Met	37	Snow	18	Most	185	Trade	18		
Put	268	Song	7	Must	50	Truth	11		
Run	101	Talk	124	Post	16				
Sat	20	True	50	Salt	12	A		A	
Set	62	Walk	67	Soft	3	Brush	6	Growth	
Old	151	Wash	5	Skin	10	Cloth	3	Praise	
Ten	136	Wing	4	Want	385	Coast	19	Source	2
War	82	Wish	20	West	40	Faint		Strain	5
Yes[a]	285	Year	335	Yard	42	Fault	16	String	
						Fifth	8	Struck	2
A		A		A		Flash		Thread	
Cat	4	Bowl	2	Flag	2	Grain	3	Tongue	
Gas	20	Dish	3	Gift	2	Hence		Wealth	4
Gun	10	Folk		List	7	Meant	10		
Hit	65	Glow		Melt	2	Quick	14		
Kid	51	Goat		Nest	1	Saint	21		
Lad		Lead		Port	2	Scale	7		
Log		Load	14	Rank	11	Sharp	7		
Nut	4	Push	13	Silk		Trace	3		
Pan		Rail		Sink	8	Track	10		
Sad	6	Shut	20	Test	35	Trick			
Wit		Slow	7	Vast[a]	5	Worse	25		

10

A		B		C		D		E	
40	H	40	H	40	H	40	H	40	H
Dad	19	Lamb		Host		Depth	4	Fierce	44
Dig	3	Luck	6	Quit	14	Feast		Scheme	
Rub	4	Sang[a]		Risk				Scream	2
Ton		Wrap[a]		Trim				Thrill	
								Thrust	
								Shield	
30		30		30		30		30	
Hut		Knit		Film		Ghost	2	Glimpse	
Lap	2	Soap	5	Palm		Roast	1	Grieve	
						Shift	5	Phrase	6
						Stuck	12		

Note.—Lists A, B, and C each contain 42 words distributed as follows according to Thorndike-Lorge (1944) categories: AA, 25; A, 11; 40, 4; 30, 2. The distribution for list D is AA, 18; A, 18; 40, 2; 30, 4, for a total of 42 words. List E contains 28 words distributed as follows: AA, 10; A, 9; 40, 6; 30, 3. H (Howe, 1966) frequencies represent the number of occurrences in 250,000 words of spoken discourse.

[a]These words were not used in the preliminary experiment.

APPENDIX B
SUPPLEMENTARY TABLES

Table B1

Analysis of Variance for Each Task Condition
in the Preliminary Experiment

	Recognition			Recall	
Source	df	MS	F	MS	F
Time (T)	1	283.22	9.22*	557.78	13.19**
Error (b)	8	30.70	5.79**	42.29	4.24**
Word Groups (WG)	4	21.48	4.79**	50.90	5.11**
T x WG	4	9.32	1.76	8.98	<1
Error (w)	32	5.30		9.96	

* $p < .05$
** $p < .01$

Table B2

Percentage of Errors for Each Condition and Word Group

Subjects	Number of Presentations	Presentation–Test Condition					
		AA	AV	VA	VV	Simultaneous V	Simultaneous A
College	1	5.2	5.2	4.0	5.4	5.0	3.5
	4	4.0	3.5	0.9	2.9		
	Combined	4.6	4.4	2.9	4.2	5.0	3.5
6th Grade	1	4.3	4.0	4.6	5.0	6.0	7.3
	4	3.5	4.5	2.7	4.0		
	Combined	4.0	4.3	3.7	4.5	6.0	7.3

Subjects	Word Groups				
	A	B	C	D	E
College	3.8	4.6	4.2	3.0	4.4
6th Grade	3.1	5.8	6.1	3.8	4.6

Table B3

Mean Intercepts for Each Condition and Word Group

Subjects	Number of Presentations	Presentation–Test Condition					
		AA	AV	VA	VV	Simultaneous V	Simultaneous A
College	1	463.35	545.69	446.70	539.46	509.02	444.64
	4	453.20	547.78	431.68	471.50		
	Combined	458.48	546.73	439.19	505.48	509.02	444.64
6th Grade	1	608.32	629.96	557.25	609.26	593.70	560.64
	4	561.38	615.90	534.71	554.24		
	Combined	584.85	622.94	545.98	581.75	593.70	560.64

Subjects	Word Groups				
	A	B	C	D	E
College	495.34	448.12	492.33	485.86	505.61
6th Grade	577.78	597.52	543.54	586.59	607.22

Table B4

Analysis of Variance of Processing Rates
in the Main Experiment

Source	df	MS	F
Between			
Age level	1	1184.7	<1.0
Squares/age	2	7186.0	1.53
Ss/Square/age	36	4635.7	3.25***
Within			
Order	9	1608.4	1.13
Word groups	4	3016.4	2.11*
Conditions	9	5248.7	
Presentation (P)	1	6003.0	4.21**
Test (T)	1	2014.4	1.41
No. of rep. (#)	1	2110.7	1.48
P x T	1	8745.1	6.13**
P x #	1	5.9	<1.0
T x #	1	1463.2	1.02
P x T x #	1	933.1	<1.0
Sim. vs Suc.	1	13102.3	9.18***
Sim. A vs V	1	12852.9	9.01***
Age Interactions			
Age (A) x Order	9	924.0	<1.0
A x Word groups	4	996.3	<1.0
A x Cond.	9	1220.2	
A x P	1	4439.5	3.11
A x T	1	11.8	<1.0
A x #	1	352.1	<1.0
A x P x T	1	2137.0	1.50
A x P x #	1	290.0	<1.0
A x T x #	1	191.5	<1.0
A x P x T x #	1	11.4	<1.0
A x Sim. vs Suc.	1	3072.3	2.15
A x Sim. A vs V	1	507.6	<1.0
Residual	317	1427.3	

* $p < .10$
** $p < .05$
*** $p < .01$

GPO 811-237-4

Table B5

Mean Processing Rate per Item for Items in Each Word Group
Under the Two Conditions of Number of Presentations

Ss	Number of presentations	Word groups				
		A	B	C	D	E
6th grade	1	55.18	40.01	69.17	52.89	55.39
	4	49.84	50.02	44.42	43.91	50.28
College	1	48.79	34.36	38.73	48.17	42.52
	4	40.14	37.69	59.31	36.31	61.63
Combined	1	51.99	37.18	53.95	60.53**	48.96
	4	44.99	43.86	51.86	40.11	55.91

Note.—The asterisks refer to the results of a *t* test between each pair of means for the combined data only (*df* = 39).

** $p < .01$

Table B6

Mean Processing Rate per Item for Items in Each Word Group
for Each Test Modality

Ss	Test modality	Word groups				
		A	B	C	D	E
6th grade	A	43.00	45.25	64.25	53.98	60.09
	V	62.01	44.45	49.34	42.81	45.57
College	A	42.63	40.35	66.54	33.92	53.72
	V	46.00	31.71	33.14	50.41	50.93
Combined	A	42.82*	42.80	65.40**	43.95	56.90
	V	54.01	38.08	41.24	46.61	48.25

Note.—The asterisks refer to the results of a *t* test between each pair of means for the combined data only (*df* = 39).

* $p < .05$
** $p < .01$

Table B7

Mean Processing Rate per Item for Items in Each Word Group for Each Presentation Modality

Ss	Mode of presentation	Word groups				
		A	B	C	D	E
6th grade	A	64.41	40.36	55.61	50.84	42.92
	V	41.91	49.64	57.99	45.95	62.74
College	A	36.16	38.56	40.41	32.50	36.81
	V	51.85	33.79	58.81	53.02	68.89
Combined	A	50.32	39.46	48.01*	41.17	40.36**
	V	46.88	41.72	58.40	49.48	65.82

Note.—The asterisks refer to the results of a t test between each pair of means for the combined data only (df = 39).

* $p < .05$
** $p < .01$

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